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Bingham, Walter Van Dyke

Measuring a workman's skill

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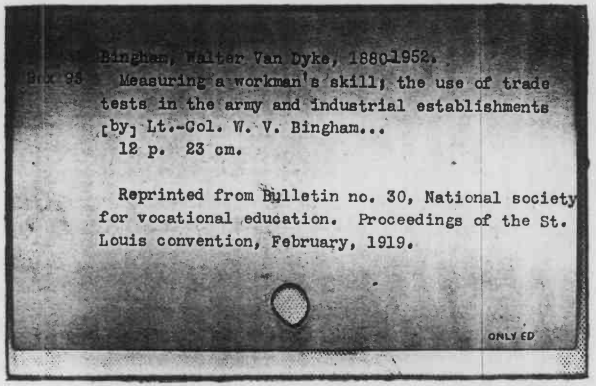
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Measuring a Workman's Skill

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THE USE OF TRADE TESTS IN THE ARMY AND INDUSTRIAL ESTABLISHMENTS

Lt.-Col. W. V. BINGHAM

Carnegie Institute of Technology and formerly Executive Secretary of the Committee on Classification of Personnel in the Army

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MEASURING A WORKMAN'S SKILL

The Use of Trade Tests in the Army and Industrial Establishments

LT. COL. W. V. BINGHAM
Carnegie Institute of Technology and Formerly Executive Secretary of the Committee on Classification of Personnel in the Army.

The development of trade testing has been one of the useful by-products of the war. It had long been recognized that waste of human life and human skill through misplacement in the army or in industry is a futile, costly extravagance; yet it requires the stress of war to make people act on this conviction that the conservation of carpenters, welders, and turret lathe operators is really more important than the conservation of water power and timber land, and that rich returns would accrue to an investment of money and talent directed toward an improvement of the technique of human classification and placement. Of the improvement in personnel technique, which has emerged from Army experience, perhaps no phase has greater promise of worth for industry than the development of standarized trade tests.

At the time of their entrance into the war, neither the British nor the American armies were prepared to give actual trade tests to recruits claiming trade experience. Neither was there full realization of the tremendous need for occupational skill in a huge and complex modern army. Electricians, chemical workers, and tool makers were assigned as sappers and riflemen, just as though the nation had an inexhaustable supply of these skilled men.

The British fatalities during the early months of the war, which included thousands of greatly needed mechanics and technicians, present a record of heroic but costly sacrifice. Later, when it was realized that large numbers of tinsmiths, foundrymen and other essential tradesmen were fighting as infantrymen in the trenches, the War Office found it necessary to withdraw them, even at serious cost of interference with the military organization and training of the combat units in which they were found. By this time most of the soldiers were quite ready to leave the lice and filth of the dugouts for army work in more

congenial surroundings; so when the word was passed down the line that tinsmiths were needed, nearly every soldier turned out to be a tinsmith: consequently, it became necessary to set up behind the lines in Flanders, trade test stations in which those soldiers who were really sufficiently skilled in the required trades could demonstrate their competence.

During the second year of the war Great Britain established as an integral part of her recruiting plan, a comprehensive system of occupational classification and trade testing. Under this plan all recruits who claimed trade skill were sent directly from their "local boards" or National Service stations, to certain army centers for technical interview and assignment to the units where they were most needed; and all men claiming trade skill in the more essential and difficult trades were sent to a single national trade test center near London. This enormous trade test station was established in the training shops of the Army Ordnance College, which adjoins the great arsenal at Woolwich. Here, day by day, machinists, blacksmiths, wheelwrights and other tradesmen recruited from all over England, Scotland and Wales, were sent to receive a practical examination of their trade proficiency.

The tests at Woolwich were supervised by experienced tradesmen, who before the war had been instructors in the army training shops. The examiner gave a rating after watching the recruit do a specified job, a job which required all the way from two to fourteen hours to complete. The recruit was then assigned to the branch of the service which at that time had greatest need for his special type of skill. Here he frequently received another and more extensive trade test, the result of which determined his particular assignment and also his grade and rate of pay. An essential feature of this second trade test, which frequently extended over a period of several days, was that it enabled the officer to determine just those elements of trade skill and knowledge in which the recruit was still deficient, and in which he needed additional training.

The conditions under which trade testing had to be undertaken in the American Army were radically different from the British. Transportation of all tradesmen to a single center was geographically unthinkable. Recruits were being received in twenty or more cantonments, each of which frequently examined and classified upwards of 2,000 men a day. It was impossible to maintain in each of these twenty receiving stations, examiners

who were skilled and competent in each of a hundred or more essential trades. This meant that the examining had to be done for the most part by examiners who did not know as much about the trade as the recruit. Yet it was essential to get reliable results in spite of these limitations. It was essential to get them quickly. It was essential that the trade rating of a soldier should be the same, no matter whether he were tested in May or in November, by Lieutenant Doe or by Sergeant Roe, in San Antonio or in American Lake. Accuracy, economy, convenience, speed, and uniformity of results were the characteristics sought in the American Army trade tests.

The group chosen by the Committee on Classification of Personnel in the Army to prepare and standardize these trade tests included men experienced in employment management, mechanical engineering, civil service examining, and psychological and statistical research. This Trade Test Division of the Committee began its work at Orange, N. J., under the leadership of Mark M. Jones of the Edison Interests, and later continued, with headquarters at Newark, under Dr. Beardsley Ruml of the Carnegie Institute of Technology, and Mr. L. B. Hopkins of the General Electric Company. These men with their twenty to thirty associates had the fullest cooperation from foremen and superintendents, and from many thousands of tradesmen in the industries of the Newark, New York, Pittsburgh and Cleveland Districts.

The standardized trade tests were first introduced into army practice last June, when there was pressing need, especially for the truck driver's and auto mechanic's tests, to determine whether the ammunition and supply trains of the divisions that were about to be sent to France really had the skilled personnel necessary to get the supplies up to the front under battle conditions. By the time that mobilization ceased in November, standardized tests in about eighty of the more important trades were in use.

The cost of production and standardization of the tests was on the average roughly a thousand dollars a trade. But as it worked out, this was an extremely economical investment for the War Department. A conservative estimate was made last October of the saving in the cost of pay and subsistence of recruits, which was at that time being effected as a direct result of the use of these trade tests. Data gleaned from the twenty cantonments in which

the trade test stations were operating, indicated that in each station the tests were saving the Depot Brigade personnel officers from making about ten erroneous assignments a day. Since it takes at least two weeks on the average to discover that a soldier, who has been sent to a technical unit is not fully competent and to effect the necessary replacement, each avoidance of such a mistake meant a saving of $42. The trade tests were then saving the Army about $210,000 a month on this item alone. But of course the real economies were not of money but of time. Correct initial placement meant speedier organization and more rapid progress of training. Trade tests had their share in the rapid shaping of army units which were ready ahead of schedule to meet the demands of Foch and Pershing on the western front.

In devising a standardized trade test it is first necessary to study the trade to find out through analysis of typical jobs, what are the elements of skill and information and judgment which combine to constitute real proficiency. The Army Trade Test Division began by assembling information from such sources as the archives of the U. S. Department of Labor, state and city civil service commissions, and the like. Suggestive typical tasks and numerous trade questions and answers were accumulated through conference with officials of trade unions that maintain standards of proficiency among their membership, and also from employment managers of large establishments. But no amount of this accumulated material could take the place of analysis made by actual observation of skilled and partly skilled tradesmen at their work.

After analysis of the trade comes construction of a tentative test. This sometimes takes the form of a performance test, a job arranged so as to require of the candidate a demonstration of his manual proficiency and his judgment in the use of the main tools of his trade.

Other tests are entirely oral, consisting of questions to elicit definite bits of trade knowledge, to sample the range of the candidate's practice, and to try the soundness of his judgment on typical matters.

A third type of test, similar in principle to the oral test, presents to the candidate pictures of tools, machines, materials and products of his trade, and requires him to identify them and to indicate uses. Thus in one of the horseshoer's tests are included pictures of a fullered horseshoe and a stamped horseshoe; a shoe

to prevent interfering, and a toe weight shoe; a pad and a hoof plate, a mule shoe, a winter shoe, and a racing plate. Besides identifying these or telling differences in their use, the candidate is shown pictures of, and asked to name or tell the use of, a pritchel, clinch tongs, a fitting hammer, a driving hammer, and a buffer; a straight hardie and a round hardie; a cold chisel and a hot chisel; a hoof expander, a toe calk, and other things familiarity with which is found to differentiate the more experienced from the less experienced horseshoer. Pictures of horses' feet in various conditions enable the candidate to show his good judgment as well as his trade knowledge, by telling how each should be treated. The examiner, keeping an exact score on the candidate's responses and referring to the standard ratings, can in ten minutes assure himself with reasonable accuracy as to whether the soldier knows as much about the horseshoeing trade as most experts, journeymen, apprentices, or novices, as the case may be.

Similarly, in an oral test for horseshoers, the soldier is asked such questions as these:

"How does a deep-seated corn usually show on a sole?" "Red," is the answer which experienced horseshoers universally give to this question.

"What is the fullering in a shoe?" "Groove" and "crease" have both been found to be acceptable answers.

"How do you shoe a horse that has a bone spavin?" "Lower the toe and raise the heels."

Questions likely to provoke narration of processes or descriptive answers that are both time-consuming and difficult to evaluate, are omitted. Only those questions are included which seem simple, clear, direct and unambiguous, and which promise to elicit answers that can be accurately scored and that will be genuinely diagnostic of trade proficiency.

After a tentative test containing sixty, eighty, or even a hundred distinct elements has been assembled it must be tried out. It is first used in testing from five to twenty men whose high proficiency in the trade is known. During this preliminary tryout the test undergoes progressive revision and refinement. Ambiguities and localisms of terminology are eliminated. Elements that require too much time or that prove to be repetitive of other elements, or that are not sufficiently diagnostic, are dropped.

The revised test is now subjected to a second and much more thorough tryout. With adherence to rigorously uniform procedure, it is administered in various establishments and in different industrial regions of the country, to no less than eighty men whose proficiency is known. Of these, twenty are experts in the trade, twenty are journeymen, and twenty are men rated as apprentices of at least fourteen months and less than three years standing. The remaining twenty are novices, persons of good education and intelligence but with no experience at the trade in question. The testing of these novices is necessary in order to discover and eliminate the elements of the test which an educated non-tradesman could pass, on the basis of his general knowledge or intelligence.

All of these test records, which show exactly what each of the eighty or a hundred men did with every element of the test, are turned over to the statistician who computes for every element its diagnostic value. He then chooses those elements which are found to differentiate most sharply between novice and apprentice, apprentice and journeyman, or journeyman and expert. He determines the best numerical weighting to be attached to each of these selected elements. And finally, combining these scores, he ascertains the critical rating which is found to separate the largest number of known apprentices from the novices, the journeymen from the apprentices, and so on. This stage of the process we have called "calibrating" the test. Like the calibration of a thermometer, the critical points of the test score are located, not by theory or by the opinion of the deviser of the test, but by actual trial. Only thus are we confident that the test will really measure trade proficiency with the degree of reliability required by the Army.

Not infrequently the tentative formulation of the test has proved inadequate, and after all the labor and expense of an elaborate tryout it had to be thrown into the waste-basket and a fresh start made. Only after a test had been devised which was found on thorough trial to measure up to the requirements, was it turned over for use with the soldiers.

It will now be obvious why it was necessary to insist upon exhaustive analysis and careful standardization. Only thus could tests be prepared which would prove reliable when administered by examiners who were not themselves experienced tradesmen. Success in this venture hinged upon the possibility of setting tasks, the performance of which would yield measurable products. According to the British theory of trade-tests, the examiner who

is testing a painter should himself be an experienced painter, competent to tell whether or not the recruit is proficient merely by watching how he goes about the mixing of his paints. The procedure, the process is judged; not the product. And it is judged subjectively, not by comparison with an objective standard.

With us the product is essential. We want something we can measure or score. For example, in the test for the structural steel erector there are ten features of the product of the test which the examiner can measure and score. The material for this test consists of a length of standard 8-inch "I" beam. The tools include a ratchet drill, a 2-pound Ball Peen hammer, 2 1-inch flat chisels, a heavy center punch, a 2-foot rule, a 12-inch adjustable hack saw frame, 3 blades (14 teeth), one ¾-inch, one 13/16-inch and one ⅞-inch Morse taper square shank drills, and one Terry Old Man with wrench. The examiner gives the candidate a blue print and says, "On this 'I' beam do as you are instructed on the blueprint." The blueprint gives the following directions: "Drill a hole in the web of this 'I' beam 1½-inches from the last hole (or from the end of the beam) and 2 inches from the top of the beam for a ¾-inch rivet. Block or cope one side of the flange. Center of saw cut should be directly over center of hole. Use hammer and chisel to finish the cope." The examiner does not need to watch the job, but when it is finished he must carefully measure with his steel square and scale the significant features of the product. Thus, if the center of the hole is located correctly within 1/16 of an inch he gives the candidate a credit of four points; if it is from 1/16 to ⅛-inch off he gets only two points; and over ⅛-inch off scores zero. He measures the dimensions from the top of the beam to the center of the hole, the squareness of the saw cut, etc., and assigns the credits indicated. He gives four points credit for using the 13/16-inch drill, but none for using the ¾-inch or the ⅞-inch. If the candidate breaks one hacksaw it costs him two points, and four points if more than two blades are broken, and so on. Throughout, it is possible for a trained examiner to give a just and accurate rating even though he himself never used a hack saw or a drill.

The final rating in this Structural Steel Erector's Test depends upon both the excellence of the job and the time required to complete it. To earn a journeyman rating, the candidate must score at least 30 points and finish within 25 minutes.

This measurement of both product and speed is typical of many of the performance tests. But some of them, such as the tests for telephone and telegraph linemen, and for magneto and ignition repairmen, place all the emphasis on the quality of the product; while in still other cases the speed with which the job is completed is found to be the significant index of trade skill. The test for steam fitters, for example, consists in making up a mitre radiator coil out of its fourteen parts. If the job is not correctly done, or if it takes more than 115 minutes, the candidate is a novice. A journeyman completes it in from 19 to 24 minutes, while if it is done in 18 minutes or less we know that the man is an expert steam fitter.

A few exceptions occur to the general rule that the examiner does not need to watch how the job is done. When testing a truck driver, an auto chauffeur or a motorcyclist, the examiner has to be seated beside the candidate, prepared to record the smoothness of starting, gear-shifting, stopping, backing, turning, driving through a maze, coasting down hill with the power off, using the engine as a brake, and so on. But even here the principle holds that the tester need not himself be a competent driver. Instead, he needs training in giving these particular tests, after which he can be trusted to get the measure of a recruit who claims to be a truck driver, in ten minutes time and with adequate accuracy.

While these trade tests were being developed, two astonishing discoveries came to light. The first of these is the rarity, the practical nonexistence, of the exclusively motor-minded type of tradesman, the man who can do the job with his hands but cannot tell you about it in words. In beginning the trade test development we had expected to meet numerous difficulties due to the prevalence among manual laborers of this variety of mental constitution. We expected to find that the oral type of tests would prove useful with the more verbally minded men; but we anticipated meeting many tradesmen of high proficiency and skill who could do little or nothing with these oral questions. This expectation proved to be wholly at variance with the facts. The problem here suggested, as to whether the so-called pure type of motor-mindedness is really only a mythical abstraction, is respectfully referred to the laboratories of educational psychology.

Parenthetically, permit me to forestall a dangerous misconstruction which might possibly be placed on these statements. I

do not for one moment imply that there are not many men who do not *learn through verbal instruction* as easily as others. We all know what a wholesome influence industrial education has brought into the schools partly through its insistence upon teaching through practice and demonstration rather than through reliance on verbal instruction. Indeed is it not significant for education that these very tradesmen, whose proficiency with their tools was universally paralleled by ability to use correctly technical terms and trade expressions characteristic of their occupations, had learned those words not from lectures or from books but from actual shop experience?

The other discovery, not wholly unrelated to the first, was the fact that in a majority of the trades the oral tests yielded more accurate differentiations of proficiency than did the performance tests. In other words, the journeyman and the expert differ from the apprentice not so much because they have greater manual skill and dexterity as because they excel in judgment, technical information, or trade knowledge.

Of course this is not the case in some occupations, such as truck driver or typist. Here oral tests are futile. The candidate must be given a chance to demonstrate his skill through actual performance. But in most of the trades the actual performance testing of the man on the manual job can be omitted without great loss to our knowledge of the man's proficiency. An oral test prepared in the manner already described is more effective than a performance test in separating journeymen from apprentices and experts. The obvious implication is that dexterity and manual facility in doing a job are relatively less important than knowledge of when to do it or which tools to choose. No generalization more suggestive for industrial education has emerged from our work than this, that superiority in trade proficiency resides more often in the head than in the hands.

What are the limitations and weaknesses of these Army trade tests?

Not even such tryouts and revisions as the tests underwent resulted in the elimination of all ambiguities, all inaccuracies, all difficulties due to localisms of practice or of terminology. The work of standardization was limited to the industrial districts in the vicinities of Newark, Pittsburgh and Cleveland.

Then too, we may say with entire frankness that many of the tests are subject to coaching. This was not a serious defect when

they were being used with soldiers who were for the most part new arrivals in the camps. But it would vitiate the results if the tests were spread broadcast, and particularly if they were available to trade instructors who might shape their courses to stress just those elements of proficiency which happen to be included in the tests.* The test is not a comprehensive inventory of a tradesman's skill. It is only a sampling. It discloses the varied excellence of his technical knowledge much as a trier which a grain inspector shoves into a carload of wheat discloses the varied quality of the grain.

Certain of the British trade tests on the other hand, aimed at making a systematic inventory of the candidate's trade ability. They disclosed his weaknesses and indicated those elements of trade knowledge or skill on which he might wisely be given additional training in order to bring his proficiency up to the desired level.

Trade tests of this comprehensive type may some day find a place of usefulness in connection with the educational program of large corporations and of trade schools. Some employment departments will find value in the briefer American Army type of standardized trade tests, provided they have the funds and the personnel to maintain a competent trade test examiner and provided they continue the expensive process of progressive revision and re-standardization which seems to be indispensible to offset the dangers of coaching.

Most employment departments will not care to undertake this program, but they will come instead to the use of an abbreviated form of oral examination which we may call the "technical interview." These technical interviews will resemble oral tests in that they will consist of precisely such questions as have been found most useful in the oral trade tests. But they will not be administered with such rigor of procedure, nor will they yield a numerical rating. They will, however, serve to clarify the interviewer's opinion of the candidate's ability, and will be a convenient and very useful first aid in employment and placement. Such technical interviews, prepared by the Army Trade Test Division at the request of the U. S. Department of Labor, have

*Since it is the intention of the Army authorities to make use of the trade tests in the Regular Army Recruiting Centers, the text of the tests, except such as are selected for publication as samples, must continue to remain confidential.

already been found useful in a model office of the U. S. Employment Service recently opened in New York City, at 28th Street and Broadway. Their use is being gradually extended to other cities. The war is over, and the stimulus it offered to intense, speedy effort in research has been withdrawn. The Trade Test Standardization Division of the Committee on Classification of Personnel in the Army is completely demobilized and its devoted personnel widely scattered, although it had completed the standardization of tests in scarcely more than two-thirds of the one hundred and twenty trades and occupations on which it was engaged. But wherever these workers have gone, whether into industry, commerce, or education, they have carried with them the Army Trade Test idea, the idea of trade analysis, of measurement, of standardization, of painstaking care in definition and specification, and of insistence on getting the facts.

Thus, thanks to the war, the scientific method brought from our laboratories into the service of the Army, will now find enlarged application to important problems of human adjustment in industry.

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